Food Marketing Policy Center

Market Structure, Price Pass-Through and Welfare with Differentiated Products

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Food Marketing Policy Center
Research Report No. 80
June 2004

Research Report Series

http://www.fmpc.uconn.edu

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Department of Agricultural and Resource Economics

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Acknowledgement

Thanks for helpful comments are due for Rob Masson and Oleg Melnikov.

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Preface

There is considerable literature on price pass-through modeling. This literature has focused on pass-through of cost shocks for homogenous products. To get results with the homogenous products case, empirical implementation has required the maintained hypothesis of competition, or agreement, in quantity modeling. A major contribution of this paper is modeling pass-through for a differentiated products market under the maintained hypothesis of price competition or price agreement. We estimate a mixed logit model for U.S processed cheese market using unbalanced panel data and implement a price pass through simulation and related consumer welfare analysis under different regimes of competition.

Key words: Market Structure, Price Pass-Through, Consumer Welfare, Mixed Logit

1. Introduction

'Pass-through' refers to the phenomenon through which a change in input cost transmits into a change in price.[1] Under perfect competition, pass through is determined by the relative demand and supply elasticities. When demand is more inelastic and supply more elastic, pass-through is greater. When input supply is infinitely elastic, pass-through is 100% in the competitive case.[2] In the case of linear demand and infinitely elastic input supply, a monopolist passes through only half of an input cost change.[3] Recognizing the importance of market structure on the price pass through, some theoretical models have analyzed the effects of cost shocks under imperfect competition primarily using conjectural variation analysis in quantity competition.[4]

Very little effort has been devoted, however, to analyzing the effect of cost change on prices in differentiated product markets.[5] Most theoretical work has focused on homogenous products with quantity competition and much of the empirical work is based on reduced form analysis using industry level data.[6]

This paper analyzes how market power influences a firm's price pass through behavior in a differentiated product market with price as the strategic variable. In differentiated product markets, all firms have some degree of market power and charge prices in excess of short-run marginal costs. This market power depends on how closely products are located in the product space and the pricing game that firms play. For a given cost shock, the pass-through rate for each firm will be different depending on each firm's unilateral market power and the degree of coordinated market power that is being exercised in the market.

In differentiated product markets, the comparative static analysis which has been extensively used in homogenous product markets will not work well because it is very difficult to estimate pricing relationships as the number of products in a market increases. Hence, we employ a different approach. In this paper, we introduce a simulation-based approach to pass-through analysis using a structural model. We estimate a mixed logit demand system.[7] Given the estimated demand surface and estimated marginal costs, we solve to obtain new equilibrium prices for hypothetical cost shocks. In fact, we estimate price pass through for two alternative pricing games, Nash-Bertrand and fully collusive pricing.[8] Finally we implement a specification test to determine which games best fit the data.

Our empirical work is for the U.S processed cheese market. For the estimation of processed cheese demand, a discrete choice model is a good option. Processed cheese is a special use product produced for sandwiches and hamburgers. The use of this cheese adds very little to the total cost of a meal.[9] Accordingly, for many consumers, the choice is not so much how much processed cheese to buy as which processed cheese to buy. To the extent this is the case, the discrete choice model is well suited for the demand side of the model.

We proceed as follows. In section II, we explain U.S processed cheese market and data. In section III, we estimate a mixed logit demand model using unbalanced panel data to accommodate the entries of new brands during

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[1] Pass through literature has developed in the area of exchange rate pass through, tax pass through, agricultural product price transmission and recently merger analysis.

[2] Here, it is implicitly assumed that manufacturers and retailers are vertically integrated. If they are separated, the assumption of constant return to scale on retailers' cost function may also needed.

[3] See Bulow and Pfleiderer (1983).

[4] Refer to Stern (1987), Katz and Rosen (1985), Besley (1989) and Deliphia and Keen (1992).

[5] Some available studies include Fershtman et al (1994), and Dhar and Cotterill (2000). The former employs a nested logit model to analyze the effects of changes in the taxation regime on equilibrium prices, firms' profits and consumer surplus in the Israeli automobile market. The later develops a model of price pass through and strategic pricing within a channel for two successive oligopolies that sell differentiated products.

[6] Sumner (1981) and Sullivan (1985) studied cigarette taxes. And Karp and Perloff (1989) investigate the Japanese TV market. Besely and Rosen (1996) studied tax pass through for various commodities in the U.S cities.

[7] Refer to BLP (1995) and Nevo (2001). Nevo(2000) applied the model for merger analysis and Petrin (2001) used the model to estimated the consumer benefits of new products in the automobile industry.

[8] Karp and Perloff (1989) explain if a researcher misspecifies strategic conduct in the market, the estimation of price pass-through can be biased.

[9] According to Gould and Lin (1994), the annual expenditure for processed cheese was \$ 20.01 for average households. This data is based on Nelsen Scan Track panel data for 8,922 households from March 1991~March 1992.

the sample period. We recover marginal cost and markup for each brand in each solution. Next, we implement counterfactual simulations of price pass-though and analyze the consumer welfare implications of our alternative solution concepts. In section IV, we discuss about the empirical results and in section V, we do a model specification test. We conclude in section VI.

2. Processed Cheese Market And Data

Processed cheese is the largest selling type among all cheese types and it is primarily sold pre-sliced in packages or in individually wrapped slices in packages.

Table 1 shows the market shares and average prices of leading processed cheese brands. Three brands- Kraft, Velveeta and Borden-are the major brands in the market. Phillip Morris with Kraft, Velveeta and other brands, has a dominant position in the market among national brands. Borden Inc is a distant second to Phillip Morris and the other national brands, such as Land O'Lakes command very small shares.

During the sample period, from the first quarter of 1988 to the fourth quarter of 1992, the volume shares of Phillip Morris's main brands, Kraft and Velveeta, decreased from 32.43 to 23.49 and from 25.49 to 19.40, while the combined share of the company decreased from 58.97 % in the first quarter of 1988 to 51.77 % in the fourth quarter of 1992. Phillip Morris recaptured some of the lost market share by introducing Kraft Free, Velveeta Light and Kraft Singles.[10] The structure of the processed cheese industry is a good test ground for a firm's strategic behavior. How does Phillip Morris position its products? Are Phillip Morris's brands closer substitutes with each other than with other brands?

Data consists of price, market share, product characteristics and demographic variables.[11] The price[12] and market share are quarterly from the first quarter of 1988 to the fourth quarter of 1992. Each city-quarter combination is defined as a market. The number of total markets in the data is 680.[13] For the analysis, 10 brands are selected. The number of brands varies from 7 to 10 depending on markets adding to the unbalanced nature of the data set. Among the 10 brands, Kraft, Borden, Velveeta and Land O'Lakes are the regular segment processed cheese brands. We also include brands from the low calories segment brands to analyze the competition by segment. These low-fat, low-calories and high-priced brands capture primarily those consumers who are very sensitive to fat level and are less sensitive to price.

Product characteristics were obtained from nutrient fact books that were published during the sample period. Demographic variables are sampled from the Current Population Survey (CPS). These include income, age, child and race.[14] We define the child variable as 1 if the age is less than 17 years old and otherwise as 0. For the nonwhite variable, its value is 1 if an individual is nonwhite and 0 if an individual is white. Income is household income divided by the number of household members.

3. Model

3.1. Demand Specification

Demand for processed cheese is estimated with a discrete choice model.[15] The demand system we use represents

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[10] The introduction of new brands would also allow it to raise prices on its existing brands because some of the demand it will lose will not go to competitors' products, but will instead go to its own new brands. Also, the brand proliferation might be used for entry deterrence as in other industries (Schmalensee, 1979, Scherer, 1982).

[11] See Table 1 and Table 2 for data summary.

[12] The price is net of any merchandising activity. Thus, a price reduction for a promotion is reflected in the price. Price is deflated using the regional city CPI and converted to real price per serving (28g). The price and quantity data were collected by Information Resources Inc.

[13] The number of cities ranges from 28 in the first quarter of 1988 to 43 in the fourth quarter of 1992.

[14] The selection of demographic variables is based on the previous studies on the cheese industry. These include Gould et al.(1994), Hein et al.1990), Gould(1992).

[15] We are closely following BLP(1995) and Nevo(2001) for demand specification.

consumer preferences for products as a function of individual consumer characteristics and characteristics of the products.[16] We assume that consumers choose one unit of the processed cheese brand that offers the highest utility and that they choose only one brand during each shopping trip. The indirect utility of consumer i from brand j at market m depends on the product characteristics and consumer: $U_{ijm}(x_{jm}, \xi_{jm}, p_{jm}, D_i, v_i : \theta)$, where x_{jm}, p_{jm} are observed cheese characteristics and prices and D_i, v_i, ξ_{jm} are observed individual characteristics, unobserved individual characteristics and unobserved cheese characteristics, respectively. And θ is an unknown parameter vector to be estimated. Following Berry (1994), we specify the indirect utility function as follows.

$$u_{ijm} = x_{jm}\beta_i - \alpha_i p_{jm} + \xi_{jm} + \varepsilon_{ijm} \tag{1}$$

where α_i is consumer i 's marginal income utility and β_i represents individual specific parameters and ε_{ijm} is a mean zero stochastic term, respectively. Thus, the parameters of the utility function are different for each consumer i.[17]

The indirect utility can be divided into two parts. The first part is the mean utility level of brand j in the market m, δ_{jm}, and the second part is the deviation from the mean level utility, which captures the effects of the random coefficients. Hence the coefficients on the mean utility function are the same for all individuals and the random component part of utility depends on the consumer's observed characteristics, D_i, and unobserved characteristics, v_i.[18]

$$u_{ijm} = \delta_{jm}(x_j, p_{jm}, \ \xi_{jm} : \theta_1) + \mu_{ijm}(x_j, p_{jm}, v_i, D_i; \theta_2 \ ) + \varepsilon_{ijm} \tag{2}$$

$$\delta_{jm} = x_{jm}\beta - \alpha p_{jm} + \xi_{jm} \tag{3}$$

$$\mu_{ijm} = \sum_{l=1}^{L} \ \eta_l D_{il} p_{jm} + \sigma_{K+1} v_{i(K+1)} p_{jm} + \sum_{l=1}^{L} \ \sum_{k=1}^{K} \phi_{lk} D_{il} x_{jkm} + \sum_{k=1}^{K} \sigma_k v_{ik} x_{jkm} \tag{4}$$

$$u_{i0m} = \xi_{0m} + \phi_0 D_i + \sigma_0 v_{i0m} + \varepsilon_{iom} \tag{5}$$

μ_{ijm} represents the interaction of price and product characteristics with the observed demographic variables D_i and unobservable individual characteristics v_i. The D_i is an $L \times 1$ vector for each individual. The unobserved individual characteristics, or v_i's, are random draws from the multivariate normal distribution, $N(0, I_{K+1})$, where $K+1$ draws for each individual corresponds to the price and product characteristics of which the dimension is $K \times 1$. We define the parameters in mean utility, β and α, as θ_1 and the parameters for interaction terms, η, σ, φ

[16] A alternative approach to solving the dimensionality problem in the differentiated product markets is to use a multi-level demand system for differentiated products (Hausman, Leonard, and Zona, 1994, Cotterill, 1994, Cotterill and Samson, 2002) which is an application of multi-stage budgeting.

[17] For the logit model, consumers have the same parameters in the utility function and the individual heterogeneity is modeled just in the error term.

[18] v_i is $(K+1)\times 1$ vector. We represent the element of v_i which interact with price as $v_{i(K+1)}$ and other elements which interact with product characteristics as v_{ik}.

as θ_2. Now the contribution of x_{jkm} units of the product characteristic to the consumer i 's utility is

$$(\beta_k + \sum_{l=1}^{L} \phi_{lk} D_{il} + \sigma_k v_{ik}) x_{jkm}.$$

The consumer's marginal utility of income is

$$\alpha + \sum_{l=1}^{L} \eta_l D_{il} + \sigma_{K+1} v_{i(K+1)}.$$

$u_{i0m} = \xi_{0m} + \phi_0 D_i + \sigma_0 v_{i0m} + \varepsilon_{iom}$ is indirect utility of outside good option.[19]

Let F be the joint distribution function of D, v and ε and then let A_{jm} represent the set of the values for D, v and ε that induces the choice of brand j in market m.

$$A_{jm} = \{D, v, \varepsilon \mid u_{ijm} > u_{ihm} \quad \forall h = 0,1,,,,J\} \tag{6}$$

If we assume that D, v and ε are independent, then the market share of brand j in market m is as follows.

$$s_{jm}(x, p, \delta; \theta_2) = \int_{A_{jm}} dF(D, v, \varepsilon) = \int_{A_{jm}} dF(\varepsilon \mid D, v) dF(v \mid D) dF(D) = \int_{A_{jm}} dF(\varepsilon) dF(v) dF(D) \tag{7}$$

Since the this integral is difficult to calculate as the dimension of the consumer characteristics increase, a simulation estimator of the integral that uses the empirical distribution instead of population density F is used

$$s_{jm}(p, x, \delta; \theta_2) = \frac{1}{N} \sum_{i=1}^{N} s_{ijm} = \frac{1}{N} \sum_{i=1}^{N} \frac{\exp(\delta_{jm} + \mu_{ijm})}{1 + \sum_{s=1}^{J} \exp(\delta_{sm} + \mu_{ism})} \tag{8}$$

where s_{ijm} is the probability that consumer i chooses brand j in the market m and N is the number of individuals sampled in each market.

3.2 Pricing Relationships: Nash-Bertrand & Collusion

Suppose that each manufacturer f in a total of F firms produces goods j=1,…., J_f and that a firm's marginal cost is constant for each product and varies across markets; mc_{jm}, then a firm's profit in market m[20] is

$$\Pi_f^m = \sum_{j=1}^{J_f} (p_{jm} - mc_{jm}) M s_{jm}(p) \tag{9}$$

[19] In this paper we define the total volume of processed cheese sold as market size and we treat the private labels and other small share brands that are not included in the analysis as the outside good. Considering that a cheeseburger costs very little more than a hamburger, an increase in the processed cheese price would not make people shift away from consumption of cheeseburgers and consume hamburgers instead. Rather, people would substitute to private labels or relatively cheaper brands that are not included as inside goods. Nevo (2001) assumed the size of the market to be one serving of cereal per capita per day and BLP(1995) use the number of automobiles sold as market size.

[20] In this paper we assume that firms solve profit maximization problem in each market separately rather than coordinate pricing across markets.

where M is market size and s_{jm}(p) is the market share of j in market m. Then we can solve the multi-product firm's profit maximization problem for the different pricing games.

First, let us assume that firms in processed cheese market behave as posited by Bertrand-Nash competition. For given prices of other brands, we will get the following first order condition in each market.

$$\frac{\partial \Pi_f^m}{\partial p_{jm}} = s_{jm} + \sum_{k=1}^{J_f} (p_{km} - mc_{km}) \frac{\partial s_{km}}{\partial p_{jm}} = 0, \quad j = 1, \ldots\ldots, J_f \tag{10}$$

When a firm produces many brands, it maximizes the sum of brands profits in the firm. So, the second term includes the impact of p_{jm} on the other brands' revenues inside the firm as well as the own price effect on its revenue. In other words a firm prices its own brands in a fully collusive fashion.

In the case of market under collusive pricing of brand cheeses, each brand has to take into account the effect of its price change on other firms' brands as well as the brands in the same firm. Hence, the first-order condition for joint profit Π_F maximization is

$$\frac{\partial \Pi_F^m}{\partial p_{jm}} = s_{jm} + \sum_{k=1}^{J_f} (p_{km} - mc_{km}) \frac{\partial s_{km}}{\partial p_{jm}} + \sum_{\substack{f'=1 \\ f' \neq f}}^{F} \; \sum_{s=1}^{J_{f'}} (p_{sm} - mc_{sm}) \frac{\partial s_{sm}}{\partial p_{jm}} = 0 \tag{11}$$

where $s = 1, \ldots\ldots, J_{f'} \quad j = 1, \ldots\ldots, J_f$

Hence, the first order conditions, (10) and (11) can be summarized in vector notation as (12).

$$(p - mc)\Delta(p) + s(p) = 0 \tag{12}$$

where p, mc and s (p) are a price vector for all brands, a vector of marginal costs of all brands and a vector of market shares. And $\Delta = J * J$ matrix with elements;

$$\begin{cases} \dfrac{\partial s_k(p)}{\partial p_j} & \text{,if brand k and j are produced by the same firm in the Nash model} \\ & \text{or by a colluder in the collusion model} \\ 0 \text{ , Otherwise} & \end{cases}$$

From (12), we can solve for marginal cost for each brand for each market conditional upon the assumed market structure such that

$$\hat{mc} = p - \Delta(p)^{-1} s(p) \tag{13}$$

So, the estimated marginal cost depends on the equilibrium price, the parameters of the demand system and Δ^{-1}, the game being played.

3.3 A Counterfactual Simulation of Price Pass-Through and Related Welfare Analysis

After recovering all the demand side parameters and marginal costs, one can simulate price pass-through using the estimated structural model. We assume that a firm's marginal cost consists two parts. These parts are an industry specific component and a brand specific component. Then marginal cost for each cheese brand j in market m is

$$mc_{jm} = mc_m + mc_j + \varepsilon_{jm} \tag{14}$$

where mc_m is a common component in the market or industry-wide component and mc_j is a brand specific component. And ε_{jm} is an iid error term. We assume that market components and brand components are independent of each other and brand -specific components are also uncorrelated for brands k and j.[21]

In this paper, we assume that there is an industry-wide common shock for each brand in each market and so marginal cost changes from $\hat{mc}$ to $\bar{mc}$. Following the cost shock, market prices will converge to new equilibrium. The new equilibrium price is:[22]

$$p_{New} = \bar{mc} + \Delta(p_{New})^{-1} s(p_{New}) \tag{15}$$

The price pass-through rate is defined as the ratio of price change to the change in marginal cost.

$$Pass\ Through\ Rate = \frac{\Delta p}{\Delta mc} \times 100 \tag{16}$$

Where Δp is the difference between the new equilibrium price that solves system (15) and the old price and $\Delta mc = \bar{mc} - \hat{mc}$. We perturb the system (15) with different sizes of marginal cost shocks. The cost shock ranges from 0.1cents/serving to 1.2 cents per serving of processed cheese.[23] As prices change correspondingly with respect to the marginal cost shocks, the welfare of consumers will also change.[24] Consumer welfare change is estimated by the compensating variation, which measures the net revenue of a planner who must compensate the consumer for the price change after it occurs, bringing the consumer back to the original utility level.[25] We estimate the consumer welfare changes for each regime of competition. Depending on the nature of competition, the price pass-through rate will be different and the size of the compensating variation will vary.

3.4 Estimation

To estimate the demand function we need to control for correlation between prices and error term in the mean utility function. It is difficult to justify a claim that price is independent of unobservable characteristics, which have the interpretation of unobserved product quality.[26]

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[21] Here, for notational convenience, we do not project the marginal cost on a firm specific component. Since we analyze an industry-wide cost shock, this assumption will not affect the results. For price pass through simulation and consumer welfare analysis, we assume that consumer's marginal utility of income does not change following cost shocks and utility from outside good also does not change.

[22] Nevo(2000) used a similar technique for merger analysis.

[23] This allows for up to approximately 10 % changes in marginal cost. See table 5 for each brand's estimated marginal cost per serving.

[24] Here, we assume that the estimated demand side parameters do not change and prices will change corresponding to the change in marginal cost.

[25] McFadden (1981), Small and Rosen (1983).

[26] The correlation between price and unobserved characteristics is positive because higher quality could lead suppliers to set higher prices. Trajtenberg (1989,1990) found that demand for CT scanners was estimated to be positively sloped with price

In the model we have to find variables that are correlated with price but are independent of unobserved product characteristics. Estimation requires an instrument vector with rank of at least the dimensionality of the parameter vectors. One of the instruments typically used is a variable that represents closeness in product space in the particular markets (BLP,1995, Bresnahan, Stern and Trajsenberg ,1997). Such instruments, however, are most appropriate for dynamically changing markets in which product characteristics evolve continuously. If a market is mature and product characteristics do not change much, then this instrumental variable will not change across markets and it will have little identifying power. Another approach is to exploit the panel structure of the data. Examples of this approach are found in Hausman (1994), Cotterill (1994) and Nevo (2001). The identifying assumption is that, controlling for brand-specific means and demographics, city specific demand shocks are independent across cities. Given this assumption, a demand shock for a particular brand will be independent of prices of the same brand in other cities. Due to the common marginal cost, prices of a brand in different cities within a region will be correlated, and therefore can be used as valid instrument variables. We follow this approach. However, we modify it in response to recent criticism.[27] If there is a national or regional demand shock, this shock will increase the unobserved valuation of all brands in all cities and the independence assumption will be violated. Also if advertising campaigns and promotions are coordinated across cities, then these activities will increase the demand in the cities that are included in the activities, so the independence assumption will be violated for those cities. Hence, to control for aggregate demand shocks, we also include time dummy fixed effects in the regression model and use them as instruments.

Let Z is N by L matrix with its row z_k and $\xi(\theta)$ is N by 1 error tem in mean utility with its row ξ_k.[28] Then the moment condition that the instrumental variables are orthogonal to the structural error, error terms in the mean utility, is used to form the GMM objective function, $E[z_k \xi_k(\theta)] = 0$. Then sample moment will be

$$\bar{m}(\theta) = \frac{1}{n}\sum_{k=1}^{n} z_k \xi_k(\theta) = \frac{1}{n} Z' \xi(\theta) \quad .$$

Now we search for θ which minimizes the GMM objective function. The GMM estimate is

$$\hat{\theta} = \arg\min_{\theta} q = [\bar{m}' W \bar{m}] \tag{17}$$

Where W is a consistent estimate of inverse of asymptotic variance of $\sqrt{n}\,\bar{m}(\theta)$.

4. Results

Table 3 shows the estimated demand side parameters. For the parameter estimates of mean utility, the coefficient on PRICE is negative and significant and FAT is positive and significant. This is possibly because the average consumer who purchases processed cheese are not sensitive to the health issues involving FAT but instead wants the richer taste from higher butterfat. However, the sensitivity to fat increases as income rises. It is captured in the negative and significant interaction term between fat and income, FAT*INCOME. SODIUM has a negative and significant effect on the mean utility.

Table 4 shows own and cross price elasticities. All estimates have the expected signs. An immediate consequence of product differentiation is that cross-price elasticities are generally positive and finite. In contrast, if products were homogenous, the cross-price elasticities would be infinite at equal prices and zero at all others. The results indicate that cross price elasticities between regular segment and low fat segment were asymmetric. Cross price elasticities of low fat segment corresponding to price changes of regular segment brands are higher than those of regular segment with respect to the price changes in low fat segment brands. This may suggest that the consumers

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because of the omission of unobserved quality, which was positively correlated with price.

[27] Refer to Bresnahan's comment on Hausman (1996).

[28] We introduce brand dummies as well as time dummies in the model. Hence, a brand specific component and a time specific component are removed from the error term in the mean utility.

who consumed regular segment cheeses were more willing to shift their demand toward low fat high priced brand cheeses when there were increases in the prices of regular segment. But consumers who usually consumed low fat segment cheeses did not change their demand much toward low price regular segment cheeses. This might have provided an incentive for Phillip Morris to introduce 3 low fat segment cheeses to capture consumers who were sensitive to fat and less sensitive to prices. Meanwhile, if we look at the cross elasticities inside the Phillip Morris company, their magnitudes are substantial especially corresponding to the price changes of Kraft and Velveeta. This suggests cannibalism among brands if only one price changes; however a joint pricing strategy across the portfolio can internalizes these cross price elasticities and produces profits.

Table 5 shows the cost estimates under the assumption of Bertrand-Nash competition and collusive pricing among branded product firms, respectively. For any given prices collusive pricing implies low marginal costs and higher markups than were found under the assumption of Nash-Bertrand competition.

Table 6 and Table 7 show the results of the estimated price pass-through rates, which are defined as percentage change in price corresponding to decreases in cost. Under collusion, the pass- through rates for all brands falls between 21 % and 34 % and its variation among firms is not wide through the entire range of the shock. Meanwhile, as the regime of competition among firms changes to Bertrand-Nash, not only do the brand level pass-through rates increase, the variation among firms also widens. When the cost shock is 1 cent per serving, which is around 10 % decrease in marginal cost, the range of pass through is 63% ~ 101%.

Relating to the previous literature on the relationship between the shape of demand curve and pass through rate, we may not be able to directly compare our results with the stylized facts in homogenous product markets because a brand's price pass through rate in our model depends on the other brands' demand surfaces as well as its own demand surface as in equation (15). The simulation results, however, indicate that median pass through rates are close to what a linear demand curve predicts. Our demand specification allows both overshooting and undershooting of price pass through, i.e, pass through rates above and below 100 %, so these results are not constrained by functional form as in the case with a linear or logarithmic demand specification.[29] Furthermore, the same brand has a different price pass through rate in different markets. This is because the shape of a brand's market share function differs across markets. The shapes of the demand curves in our model are determined by the product characteristics and the distribution of consumer characteristics. So, the demand specification we use here provides a very flexible analysis of price pass through across markets.

Table 10 shows the consumer welfare change which is estimated by the compensating variation after a shock that decreases marginal cost. CV1 and CV2 represent the compensating variations under Bertrand-Nash equilibrium and collusive pricing, respectively. The CV is 0.73 cents per person for a 1 cent marginal cost decrease under Nash price competition while it is 0.24 cents under collusive pricing. The ratio of CV2 to CV1 is 33%. So, under collusive pricing, the increase in consumer welfare following a cost decrease is 33% of that in the Bertrand-Nash equilibrium.

Since our model is symmetric, the price increase corresponding to cost increases is higher under Nash-Bertrand competition than under collusive pricing and a cost increase hurts consumers less when pricing is collusive (Table 11). A policy implication of this result is that we should not always view a high increase in price following an unfavorable shock as evidence of collusive market power. Rather, it may be an evidence of Nash-Bertrand competition in a differentiated product market.

5. Specification Test: A Test of the Maintained Competitive Hypothesis

In this paper we have estimated brand level marginal costs under two alternatively assumed pricing regimes. Here we test to determine which pricing regime more closely fits observed pricing conduct. Our specification test is[30] to evaluate which set of estimated marginal costs best represents the potentially true marginal cost. R^2 values are used to evaluate the predictive power of sets of cost parameters resulting from estimation under the competing conduct assumptions and an F-statistic is used to establish whether the marginal cost parameters resulting from each model are

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[29] See Cotterill et. al. (2001) for analysis of this issue.

[30] The way to structure a specification test can depend on model structure. For example, Bresnahan (1987) used a likelihood ratio test of a non-nested hypothesis for the U.S automobile industry.

statistically different from one another.

Table 12 shows the results of regressions of predicted marginal costs on factors which should affect marginal costs. For each regression, we include wage, electricity price, milk price, diesel fuel prices, brand dummies, and city specific dummies. We also include the ratio of unit sales to volume sales to take into account the economies of size that occur when consumers buy bigger packages of cheese. Wage is the Employment Cost Index for non-durable goods manufacturing sector and Electricity is the PPI (Producer Price Index) for industrial electric power and Diesel fuel is the PPI for #2 Diesel fuel. These were obtained from BLS(Bureau of Labor Statistics) indices. The milk price is the raw milk price from the USDA federal milk order statistics. In terms of R^2 values, we see that the estimated marginal cost under Nash-price competition better represents the real world cost data. The R^2 value for the specification for Nash price competition is 0.31 and that for collusive pricing is 0.20. Hence the fit for Nash price competition is 0.11 higher than that for collusive pricing. However, if we want to conclude that the estimated marginal cost from Nash price competition model has a better fit, we need to prove that the coefficient estimates of two regressions are different. This implies that the relationship between marginal cost and its components are different between Nash price competition and collusive pricing.

To test the difference of the coefficient estimates between the two regressions, we employ an F-test which has been used for tests of structural change. Our test is an analogue of a test for structural change even though the values of independent variables are the same for both the regimes. To implement an F-test, we save the sum of residual squares from separate regressions for Nash price competition and collusive pricing. We then pool the two samples and rerun the regression and save the sum of residual squares again and we calculate the following F-statistic.

$$F[65,11338] = 47.16 \tag{18}$$

This test rejects the null that the coefficients estimates from two regimes of competition are same at 1 % level. Hence, we have verified that the firm conduct in the real world in the processed cheese market appears to be closer to Nash price competition than collusive pricing.

6. Conclusion

Our main contributions to the price pass-through literature are three-fold. First, we extend the price pass-through analysis into a price competition model of a differentiated products market. Previously, such an analysis has been mostly limited to homogenous goods markets analyzed with quantity conjectures models. Second, We use a flexible demand specification that captures the effect of demand surface curvature on pass through rate. Finally, we use a simulation-based analysis of price pass-through because the comparative static analysis which has been used extensively in homogenous product markets will not work well in a differentiated products market as the number of products in a market increases. And one has very few brand level cost variables to identify complete models of demand and supply side interaction.

We have focused here on the Bertrand-Nash equilibrium and collusion. Similar studies would be possible of other equilibrium concepts such as semi-collusion and a firm's deviation to or from collusion using a cost shock as a focal point. A related avenue is a dynamic model that could account for changes in firms' strategies over time. Still another direction for research is to analyze pass through rate from manufacturer to retailer and from retailers to consumers. In this paper we assume that manufacturers and retailers are vertically integrated.

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Table 1. Market share, Prices and Product Characteristics

	Market Share	Price	Calories	Fat (g)	Choles-terol (mg)	Sodium (mg)
Kraft(P)	0.2909	14.197	90	7	25	380
Velveeta(P)	0.1987	12.230	90	6	25	400
Light N Lively(P)	0.0088	17.334	70	4	15	406
Kraft Free(P)	0.0310	16.541	42	0.3	5	273
Kraft Light (P)	0.0169	15.348	70	4	20	160
Velveeta Light(P)	0.0224	12.186	60	3	15	430
Borden(B)	0.0662	12.931	80	6	20	360
Lite Line(B)	0.0061	19.456	50	2	15	171
Land O'lakes(L)	0.0064	11.990	110	9	26	430
Weight Watchers(H)	0.0059	15.376	50	2	7.5	400

Note: Market share and price are the medians for all city-quarter markets. The unit of price is cents per serving(28g). P: Phillip Morris, B: Borden Inc, L: Land O'Lakes, H: HJ Heinz Co.

Table 2. Demographic Variables

	Median	Mean	Std	Min	Max
Log (Income)	7.835	7.838	0.905	0.405	10.742
Log (Age)	3.465	3.241	0.940	0	4.564
Child	0	0.255	0.436	0	1
Nonwhite	0	0.155	0.362	0	1

Table 3. Demand Parameter Estimates: Mixed Logit

Parameter Estimates			Standard Errors
CONTANT	-6.4305	**	0.8255
PRICE	-6.9269	**	0.9207
FAT	0.5990	**	0.0825
SODIUM	-2.1397	**	0.1674
INCOME	20.6871	**	9.8835
NONWHITE	-5.9528	**	1.6391
PRICE*INCOME	-20.0635	**	6.8385
PRICE*INCOME^2	9.1480	**	3.2117
PRICE*AGE	-2.1751	*	1.4795
PRICE*CHILD	2.5205	*	1.3550
FAT*INCOME	-0.1490	**	0.0419
CONSTANT* v_1	0.9280		1.0675
PRICE* v_2	1.9152	**	0.6817
FAT* v_3	2.6675	*	1.3746
SODIUM* v_4	3.0215	*	1.5379

Note: * t-value > 1, **: t-value >2

Table 4. Own and Cross Elasticities

		Regular Segment				Low Fat Segment					
		Kraft(P)	Velveeta(P)	Borden(B)	Land O'Lakes(L)	Light N Lively(P)	Kraft free(P)	Kraft Light(P)	Velveeta light(P)	Lite Line(B)	Weight Watchers (H)
Regular Segment	Kraft(P)	-4.705	1.645	0.844	0.236	0.027	0.156	0.198	0.251	0.007	0.034
	Velveeta(P)	1.276	-5.853	0.961	0.197	0.033	0.207	0.201	0.482	0.010	0.048
	Borden(B)	1.515	1.060	-7.864	0.242	0.030	0.221	0.226	0.350	0.010	0.054
	Land O'Lakes(L)	1.214	1.023	2.217	-8.531	0.049	0.180	0.601	0.434	0.011	0.057
Low Fat Segment	Light N Lively(P)	0.660	0.521	0.232	0.034	-3.894	0.092	0.067	0.114	0.021	0.020
	Kraft free(P)	0.115	0.838	0.410	0.032	0.025	-5.803	0.201	0.303	0.010	0.060
	Kraft light(P)	0.604	0.579	0.780	0.190	0.025	0.351	-7.550	0.308	0.012	0.051
	Velveeta light(P)	0.872	0.914	1.002	0.133	0.046	0.426	0.261	-8.321	0.016	0.084
	Lite Line(B)	0.148	0.192	0.099	0.010	0.026	0.049	0.028	0.049	-4.994	0.009
	Weight Watchers(H)	0.246	0.666	0.857	0.087	0.043	0.512	0.266	0.464	0.020	-7.216

Note: Elasticities are median values for all markets; P: Phillip Morris, B: Borden Inc, L: Land O'Lakes, H: HJ Heinz Co. Row is i and column is j. Each cell (i,j) gives the percent change in market share of brand i corresponding to a 1 percent change in price of brand j.

Table 5. Marginal cost, Markup and Margin

	Nash-Bertrand			Full Collusion		
Brand	MC	P-MC	(P-MC)/P*100	MC	P-MC	(P-MC)/P*100
Kraft(P)	7.824	6.075	42.719	4.695	9.788	68.318
Velveeta(P)	6.686	5.528	45.111	4.102	8.460	67.797
Light N Lively(P)	10.317	6.177	36.938	7.083	10.105	58.535
Kraft Free(P)	10.566	5.489	35.075	7.722	8.289	52.483
Kraft Light(P)	9.352	5.314	36.345	6.166	8.572	59.298
Velveeta Light(P)	7.738	4.498	37.971	4.877	7.487	61.957
Borden(B)	11.265	1.623	12.721	4.204	9.026	67.853
Lite Line(B)	18.129	1.889	10.582	10.140	9.601	49.276
Land O'Lakes(L)	10.555	1.374	11.695	3.560	8.400	70.888
Weight Watchers(H)	12.892	1.957	12.577	5.574	9.500	63.103

Note: Median values for all markets; P: Phillip Morris, B: Borden Inc, L: Land O'Lakes, H: HJ Heinz Co. Marginal costs and markups are cents per serving.

Table 6. Pass-Through Rate (Nash-Bertrand) : Cost decrease[1]

Kraft(P)	87.36	88.42	89.19	88.76	88.64	88.53
Velveeta(P)	84.16	85.12	84.92	84.64	84.54	84.25
Light N Lively(P)	75.12	78.48	78.51	76.35	75.38	72.43
Kraft Free(P)	70.97	67.64	65.29	65.93	67.40	57.09
Kraft Light(P)	79.36	80.37	80.49	80.22	79.12	73.09
Velveeta Light(P)	82.48	83.44	83.40	82.56	82.03	76.07
Borden(B)	101.35	101.21	101.35	101.15	100.71	99.64
Lite Line(B)	47.99	61.31	66.63	68.76	79.55	85.87
Land O'Lakes(L)	20.01	35.27	46.19	48.40	78.88	94.66
Weight Watchers(H)	6.41	26.93	35.64	44.73	63.41	79.75
MC shock	0.2	0.4	0.6	0.8	1.0	1.2

Table 7. Pass-Through Rate (Collusion): Cost decrease

Kraft(P)	30.37	30.85	30.74	30.93	30.42	30.19
Velveeta(P)	28.97	29.27	29.18	29.24	28.74	28.57
Light N Lively(P)	25.46	25.90	26.08	26.13	26.45	26.78
Kraft Free(P)	34.80	31.23	28.59	25.91	26.98	25.07
Kraft Light(P)	31.29	32.23	30.98	29.49	30.34	29.87
Velveeta Light(P)	29.22	30.84	30.97	31.27	30.83	29.97
Borden(B)	30.16	30.54	30.45	30.38	30.12	29.23
Lite Line(B)	22.87	23.61	23.72	24.69	23.70	24.29
Land O'Lakes(L)	21.38	22.53	22.29	21.26	21.25	20.30
Weight Watchers(H)	26.08	26.64	26.83	25.98	25.45	25.21
MC shock	0.2	0.4	0.6	0.8	1.0	1.2

[1] %, Median values for all markets. P: Phillip Morris, B: Borden Inc, L: Land O'Lakes, H: HJ Heinz Co. Marginal cost shocks are cents per serving.

Table 8. Pass-through Rates (Nash-Bertrand) : Cost increase[2]

Kraft(P)	87.95	90.04	90.86	90.84	92.33	92.83
Velveeta(P)	84.30	85.88	87.14	87.30	88.43	88.48
Light N Lively(P)	76.21	78.35	82.04	83.17	83.95	86.98
Kraft Free(P)	79.96	82.50	86.36	88.62	87.85	88.48
Kraft Light(P)	88.63	89.40	90.39	92.21	93.48	94.77
Velveeta Light(P)	84.04	86.84	87.41	89.02	90.68	91.20
Borden(B)	102.67	103.24	103.76	104.06	104.32	104.63
Lite Line(B)	50.83	61.65	64.38	68.44	72.27	74.73
Land O'Lakes(L)	92.87	94.11	97.34	97.94	98.77	99.35
Weight Watchers(H)	59.50	74.31	84.66	89.25	92.27	94.24
MC Shock	0.2	0.4	0.6	0.8	1.0	1.2

Table 9. Pass through Rates (Collusion): Cost increase

Kraft(P)	34.47	35.36	36.04	36.98	37.77	38.38
Velveeta(P)	32.98	34.12	34.67	35.33	35.92	36.33
Light N Lively(P)	29.79	31.34	32.60	33.13	35.06	35.69
Kraft Free(P)	44.97	48.48	51.34	51.49	52.16	53.70
Kraft Light(P)	48.96	48.79	50.12	52.18	52.52	52.96
Velveeta Light(P)	44.00	45.94	47.07	46.80	47.77	47.87
Borden(B)	32.37	34.09	34.57	35.16	35.91	36.87
Lite Line(B)	27.02	30.50	32.64	33.35	33.70	35.19
Land O'Lakes(L)	24.71	27.17	28.41	28.61	29.65	30.87
Weight Watchers(H)	31.64	33.88	36.30	37.64	37.96	39.26
MC Shock	0.2	0.4	0.6	0.8	1.0	1.2

[2] %, Median values for all markets. P: Phillip Morris, B: Borden Inc, L: Land O'Lakes, H: HJ Heinz Co. Marginal cost shocks are cents per serving.

Table 10. Compensating Variation: Cost decrease[3]

Bertrand-Nash (A)	0.14	0.29	0.44	0.58	0.73	0.86
Collusion (B)	0.05	0.10	0.15	0.19	0.24	0.29
B/A(%)	34%	34%	33%	33%	33%	33%
MC Shock (Cents)	0.2	0.4	0.6	0.8	1.0	1.2

Note: Cents/per serving /per person

Table 11. Compensating Variation: Cost increase

Bertrand-Nash (A)	-0.14	-0.29	-0.45	-0.60	-0.75	-0.91
Collusion (B)	-0.05	-0.10	-0.15	-0.20	-0.26	-0.32
B/A(%)*	34%	34%	34%	34%	34%	35%
MC Shock (Cents)	0.2	0.4	0.6	0.8	1.0	1.2

Note: Cents/per serving/per person.

[3] Median values for all markets.

Table 12. Specification Test

	MC_{Nash}	$MC_{Collusion}$
Constant	-14.949	-61.967
	(-6.47)**	(-10.81)**
Wage	-0.231	-0.376
	(-3.52)**	(-2.28)*
Electricity	0.275	0.744
	(4.90)**	(5.26)**
Milk Price	0.411	0.586
	(4.41)**	(2.51)*
Diesel Fuel	0.064	0.005
	(7.73)**	(0.25)
Unitsales/Volsales	3.058	2.867
	(4.94)**	(1.85)
R^2	0.312	0.201

Note ( ): t-values; Both regressions include brand dummies and city specific dummies;
*: significant at 5 % level, **: significant at 1 % level

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